CHAPTER 5

EVALUATING SOURCES AT PROJECT SITE

5-1. General. Projects requiring large volumes of rock for massive structures such as embankments use rock from required excavation or develop a source quarry on adjacent Government land. These prospective new sources are untested with respect to the suitability of rock and the available volumes, so that they must be investigated in considerable detail. Investigations are conducted by the CE geotechnical staff, either by contract studies or with in-house personnel and drill crews. Where the volume of rock is very large, an FDM or appendix on quarries and rockfill characteristics may be needed.

5-2. Geological Mapping.

a. Geological mapping and characterization of rock materials exposed in outcrops are essential parts of project site selection studies or detailed investigations focused on project design. An accurate picture of geology of the project area is developed and integrated with the specifics on rock strength and variability, joint spacings and orientations, weathering effects, and landsliding. Mapping coverage normally extends outward from the immediate project to the surrounding area influencing or influenced by the project and encompasses sites situated properly for supplying stone or rock fill.

b. Geological details should be expanded from those described in a. above in any areas pinpointed specifically as prospective quarry sites. This increased scrutiny and documentation at potential quarry sites should at a minimum provide all rock types and adequate descriptions of surficial weathering, hardness, and joint spacings sufficient to draw cross sections and to understand the subsurface conditions in three dimensions. Volumes of rock in place can then be calculated. This requirement for subsurface projections are seldom satisfied by surface mapping alone, and core drilling is usually a necessary supplement.

5-3. Subsurface Investigations.

a. Core Drilling.

(1) The most effective means of obtaining subsurface information is by core drilling to recover continuous samples of rock (CE-1201). Core drilling is costly and mostly limited to post-authorization studies where it is often indispensable. Most core drilling is done in preparation of DM’s and is done not only in foundation areas at the immediate project site, but also in the surrounding area to a radius of several thousand feet depending on project study requirements. Numerous uses and methods of core drilling and documentation in project investigations are explained in EM 1110-1-1804. Associated techniques such as borehole photography and pressure testing, occasionally useful in evaluating stone sources, are also reviewed there.

(2) Since rock materials taken from required excavation are usually explored thoroughly in the course of core drilling to define engineering characteristics and boundaries of rock to be excavated, additional holes specifically for outlining the source of stone are unnecessary. Factors related to quarrying and production of stone are included for characterization at the

time the coring is accomplished. These product-related factors center on natural joint spacing as well as quality and variation in quality of intact stone.

(3) The standard NW-size core of 2.15-in. diameter is ideal for evaluation of stone sources. Tests for unconfined compressive strength may be made and the core is large enough for observing the degree and arrangement of jointing. Larger core may be useful for other testing and will sometimes reveal more details in zones of soft or fractured strata. Vertical holes are standard for defining stone sources, although inclined holes may be more practical on steep slopes or where the geological structure of the rock mass is suited to the use of inclined holes. The inclined holes are best for intercepting and characterizing predominantly vertical joints but are more costly.

(4) Engineer Manual 1110-1-1804 reviews the information to be included when logging core and quantitatively accounting for drilling observations and zones of poor core recovery. Each stratum or lithological unit should be described systematically for formation designation, rock type, hardness and degree of weathering, texture and structure, and evidence of material instability such as a tendency to slake after exposure. These general characteristics are always important, but extra emphasis must be placed on joint-related features. Such features as joint spacing, joint orientations, fissure width, fissure filling, alteration, and secondary mineralization along joints all relate to the character of the rock eventually produced from the source. The optimum picture can sometimes be developed by combining stratigraphy and structure from core drilling with jointing details from cores and surface outcrops.

b. Pits and Calyx Holes. Calyx holes and pits are occasionally drilled or excavated to investigate a potential rock source. The fresh, large exposure is especially useful since the undisturbed sidewall can be mapped, photographed, and studied in its entirety. A calyx core, typically about 3 ft in diameter, also presents an exceptional sample for examination and testing.

c. Geophysical Surveys. Geophysical surveys are an option for subsurface investigation occasionally useful as a supplement to core drilling. Engineer Manual 1110-1-1802 reviews methods and equipment but recognizes the importance of past experience with specific methods in obtaining valid results.

5-4. Test Quarry.

a. A test quarry may be feasible where large quantities of rock will be needed. Test quarries range from little more than large test pits up to excavations of hundreds of thousands of yards accounting for as much as ten percent of all required excavation. A test quarry is useful where there are questions about the suitability of rock, especially in required excavations, and is often made in conjunction with test fills exploring ultimate placement (paragraph 5-5). Test quarries also provide information on cut slope design, appropriate blasting techniques, and methods for processing materials. Results of quarry tests help designers and prospective bidders anticipate effective drilling and blasting methods and the characteristics of the rock. A well conducted test program is useful but expensive. Consequently, a test quarry, if possible, is always located within the required excavation or

planned quarry and the product is used directly or stockpiled for later use. Conditions must be representative of the large volume to be excavated later so that results are generally applicable.

b. The upper fragment size is fixed by geological factors. Other sizes and gradations can be influenced by the blasting techniques as explained in EM-1110-2-3800. If smaller rock sizes are needed, fragmentation may be increased in several ways.

(1) Increase the powder factor.

(2) Vary the blasthole spacing or burden.

(3) Modify the firing sequence or delays.

(4) Use high-velocity explosive or blasting agent.

(5) Add satellite blastholes.

c. Assuming that the source has been confirmed by mapping and drilling to have adequate volume and suitable upper block size, the product characteristics needing investigation by test quarrying are the overall size gradation, the yield or percentage of critical size classes, and the overall rock quality. One or more of the blasting parameters indicated above are varied in test shots. For each test, the blasted rock is gathered, sized or screened, and weighed to obtain gradation. As individual tests are completed and gradations are determined, modifications to the blasting techniques can be made. The final results are used to determine which combinations of blasting parameters fulfill design requirements.

5-5. Test Fills. Test fills are utilized as an optional design technique for evaluating the suitability of stone for embankments. Preliminary information is developed on the rock fill as it will be used in construction. Among controlled variables are fill lift thickness, number of passes, compaction equipment type, and test-quarry parameters. Results are evaluated in terms of material degradation, segregation, density, grain-size distribution, and operational problems. Engineer Manuals 1110-1-1804, 1110-2-1911, and 1110-2-2300 explain test fill programs and how they are integrated with a test quarry program. The important measurement of in-place density is described in paragraph 6-3f.

5-6. Estimating Volumes.

a. The quantity of rock material available at a new site must be carefully estimated. Difficulties such as deterioration of quality or the presence of water may arise which can reduce the estimated output. For this reason, quantity estimates should be conservative, and it is necessary to select a site containing a greater volume than is required, rather than one which is estimated to meet the immediate requirements.

b. The volume is estimated by selecting a horizontal reference plane, such as excavation grade or a convenient quarry floor level, and computing the volume by summing among parallel vertical cross sections or smaller triangular prismatic increments. Thickness of the deposit is normally tied directly to

core borings which also form the vertical edges of the volumetric prisms. Overburden and weathered rock should be carefully delineated and excluded from rock volume calculations. Separate gradation zones may sometimes be distinguished on the basis of detailed core logs provided there is a need for separate materials and a capability of quarrying those zones individually. To convert from quantity in place to quantity when broken, a multiplying factor is usually needed. Volume bulking factors for fresh rock average about 1.4, but specific values range widely. An accurate estimate may be based on experience or on a measurement obtained in a test quarry or test fill.

5-7. Environmental Constraints. Engineer Manual 1110-2-38 emphasizes the preservation of environmental quality in all project work. Accordingly, the evaluation of a potential stone source should consider the extent that a quarry development might detract from natural beauty and otherwise cause environmental concern during and after operation. The quarry area should be graded and landscaped as practicable to restore a natural appearance and to control erosion upon closure.